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Free will, the quantum and the cosmos

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The scientific media have recently reported a proposal (http://arxiv.org/abs/1310.3288) aimed at closing the "free-will loophole" in Bell experiments with light coming from distant quasars. Wow: free will, quantum mysteries and the cosmos in a single paper! This could only make headlines!

Let me take you on a tour to understand what this is about. The idea that some form of "free will" (in precise jargon, "measurement independence") is required for a Bell test to be meaningful is not new: John Bell himself stressed it. But I dare say that Francis Bacon and Galileo, and probably even Aristotle, had understood measurement independence — not as applied to Bell tests, for sure, but more modestly as a cornerstone of the scientific method. If you measure the position of a star, you assume that the star is not changing its behavior just because it is being observed. If you drop a stone from different heights, you assume that the stone does not adapt its motion to the height you dropped it from. Think what would be left of physics and chemistry, if matter could look around, guess which experiment it is going to be submitted to, and rapidly cook up an adaptive strategy. And why do you think biologists try not to be seen when they observe the behavior of animals who, contrary to stones, might indeed adapt to the observers' presence? Well, you got the point.

Still, when it comes to quantum physics, some results are so counter-intuitive that some people are ready to doubt of everything. Would it be possible that the famous two entangled photons, at the moment of leaving the source, are aware of the measurement they are going to be submitted to? Or reversing the roles, is it conceivable that the photons actively influence the random number generators that choose the measurements, in order to bias the choice towards a favorable one? Are photons closer to zebras than to stones? Raise this kind of concern with electric trains and robots, and you get rightly classified in the paranormal category. Raise it with entangled photons, and it becomes respectable science (yes, I ride on it too (http://arxiv.org/abs/1202.3571)).

Anyway, let's continue playing the game. I play the guy who is strongly suspicious of a conspiracy between the thing you call "a source of entangled photons" and the things you call "random number generators" (RNGs). Can you do something to convince me that my suspicions are not founded? If I am absolutely paranoid, you can't: super-determinism or Matrix-like simulations cannot be falsified by observation. But suppose I am willing to concede something. Specifically, I concede that the RNGs are really initially uncorrelated from the source. Then, measurement independence can only be violated if some signal propagates from the RNGs to the source. Haha, here you catch me: every signal must propagate at the speed of light (OK, OK, I concede you also that one). So, if the suitable space-like separation is guaranteed, the signal will never arrive to the source on time: the photons have left the source without knowing which measurements await them. Measurement independence is guaranteed. This reasoning was first explicitly made (to my knowledge) in a paper by Zeilinger's group (http://arxiv.org/abs/0811.3129). It is nice science: state assumptions and derive falsifiable consequences.

But now… hmmm… maybe I want to come a little bit back on my concession: maybe you can try and convince me that the random number generators are really independent of the source, at least up to some degree of confidence. You think and… I SAID YOU THINK: pause and think how you would try to convince me, before continuing!

Got it? OK, let's compare our answers.

What I would like to see is a SIMPLE random number generator, something I can reasonably trust. A resistor directly connected to an oscilloscope, showing a trace that behaves like thermal noise, maybe would do it; or a visible light beam sent on a bulky beam-splitter before reaching some detectors. Or, if I don't trust electronics (maybe the conspirators use the power network of your city), I may be happy with a grain of pollen performing brownian motion. Or maybe you are so kind that you go all the way and ask two human beings to act as random number generators (although, as well known, we humans are not great at generating randomness). I know well that all these options are questionable, but again, if I don't concede that there can be randomness somewhere, you won't be able to convince me of the opposite.

What probably would NOT convince me is to be shown a set of two telescopes pointing at some distant points of the universe, connected with all kind of filters and electronics, accompanied only by your plead of "trust that the only signal that is detected at the end of the measurement chain is that of some very distant quasars, who have not talked to each other nor to any matter here on Earth since billions of years".

Still, who can resist at the charm of having free will, quantum mysteries and the cosmos in a single paper?

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